The Lakes of Sammamish

A Report on Water Quality Monitoring Results for Water Year 2009 at Pine and Beaver Lake

Prepared for the City of Sammamish
by the King County Lake Stewardship Program

January 12, 2009

King County

Overview

The King County Lake Stewardship Program and its predecessor programs have worked with volunteer monitors for more than 17 years on Pine Lake and the two basins of Beaver Lake within the City of Sammamish. The water quality data indicate that in general Pine Lake and Beaver-2 are low to moderate in primary productivity with good water quality, while Beaver-1 has been and continues to be highly productive, indicative of the inputs from the nearby wetland that constitutes it major surface water source.

Both Beaver Lake and Pine Lake have public access boat launches and parks with beach front, where members of the public are able to access the lake. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae that could be produced in the lake. A second measure is the nitrogen to phosphorus ratio (N:P), which is used to predict what groups of algae may become dominant in the lake during certain periods. Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The discussion in this report focuses on the 2008 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Or can be provided in the form of excel files upon request.

Beaver Lake

In the mid-nineties, residents at Beaver 1 (small northern basin) and Beaver 2 (large basin) Lake began monitoring water quality through participation in the King County Lake Stewardship Program (KCLSP). Volunteer monitoring efforts continued through 2008. Physical and chemical data collected through many years of monitoring suggest that this small lake in the city of Sammamish is moderate to high in primary productivity (mesotrophic-eutrophic), with fair water quality.

Physical Parameters

Excellent precipitation and water level records for Big Beaver Lake (Beaver 2) were compiled for the 2008 water year. Water levels in Big Beaver Lake responded to high winter storms events but the outlet allowed water to drain quickly from the lake making water levels fairly static. Overall, the lake follows the regional pattern of winter high - autumn low stands. Precipitation and lake level data collected suggest the lake does rise with the onset of autumn rains and remains slightly elevated through the winter and into spring. However, the range of lake level variation through the year is relatively small, and the highest lake levels don't usually persist longer than a week or two (Figure 1).

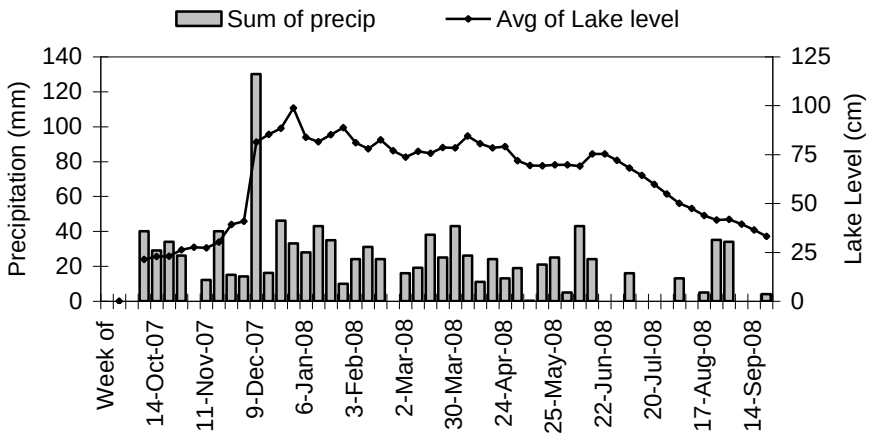

Figure 1. WY 2008 Big Beaver Lake Level and Precipitation

Little Beaver Lake (Beaver 1) did not collect daily precipitation or lake level.

Big Beaver Lake volunteers collected weekly temperature and Secchi transparency data throughout 2008 as well as the data collected by the "Level 2" volunteer, who collects water samples for laboratory analysis as well as physical data from early May through late October. Secchi transparency ranged between 2.0 and 3.1 meters. The average was 2.0 m, which placed it in the low range for monitored small lakes in 2008 (Figure 2).

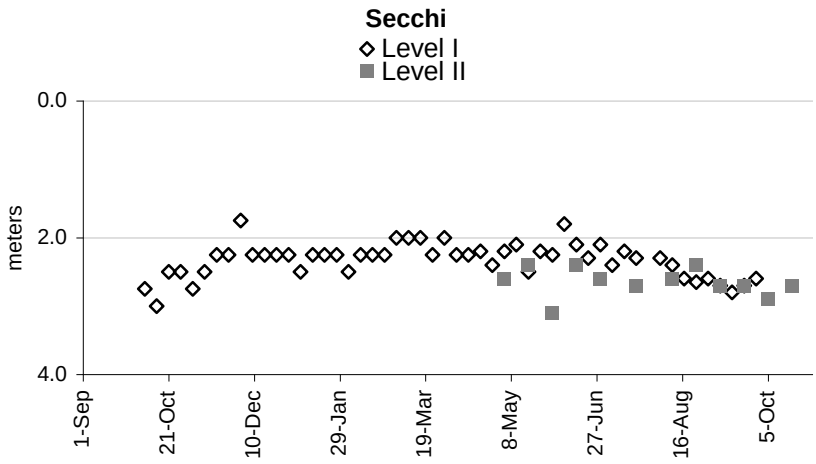

Figure 1. Big Beaver Lake Secchi Transparency

Surface water temperatures ranged between 4.0 to 25.0 degrees Celsius over 2008 with the average being 12 degrees Celsius (Figure 3). The recorded maximum temperature was in the higher range of values reported among the group.

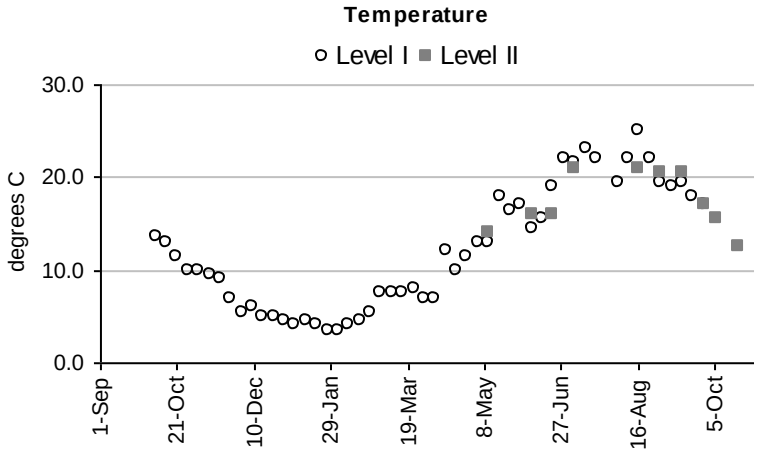

Figure 3. Big Beaver Lake Water Temperatures

Little Beaver Lake (Beaver 1) was monitored for Secchi transparency and water temperature during the Level 2 monitoring season from early May to the end of October 2008. Little Beaver Lake transparency ranged from 0.7m to 1.5m with an average of 1.2 m (Figure 4). Little Beaver Lake is at the lower end of clarity for other small lakes monitored by the KCLSP in 2008.

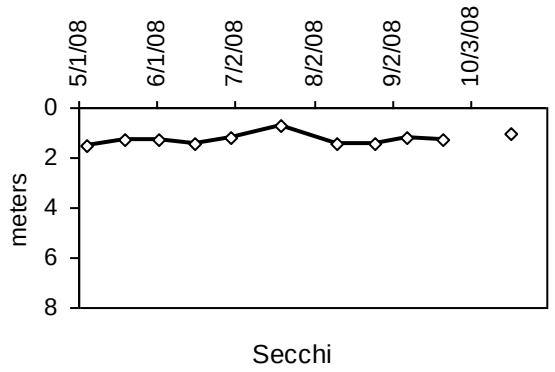

Figure 4. Little Beaver Lake Secchi Transparency

Temperatures for Little Beaver Lake ranged from 14.5 degrees Celsius to 22.5 degrees Celsius with an average of 17.8 (Figure 5). This puts Little Beaver Lake into one of the cooler recorded lakes for the 2008 water year.

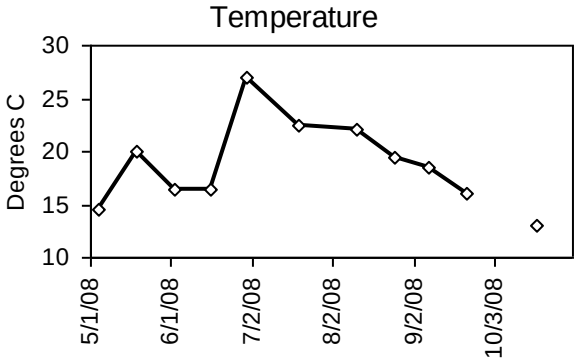

Figure5. Little Beaver Lake Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

During the monitoring period for Big Beaver Lake, TN values relatively stable with very small fluctuations with a small peak in late fall. TP was highest in the October sampling events and was relatively stable throughout the rest of the season (Figure 6).

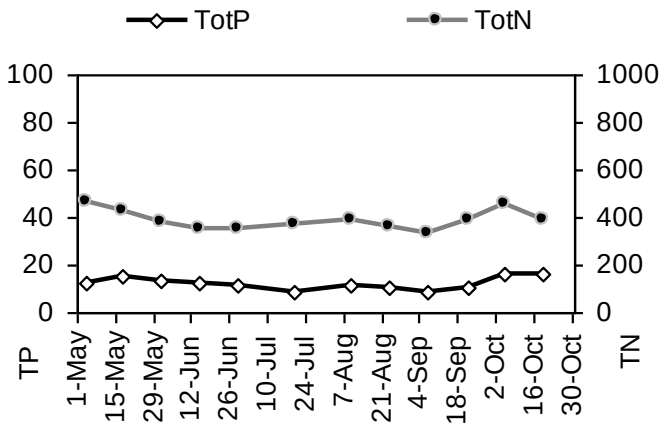

Figure 6. 2008 Big Beaver Lake Total Phosphorus and Total Nitrogen Concentrations

Little Beaver Lake had a different pattern with much higher levels overall of both TP and TN. TN was elevated early in the sampling season and had a spike at the end of July. TP was elevated earlier in the season and then declined until the end of October when a slight increase occurred (Figure 7).

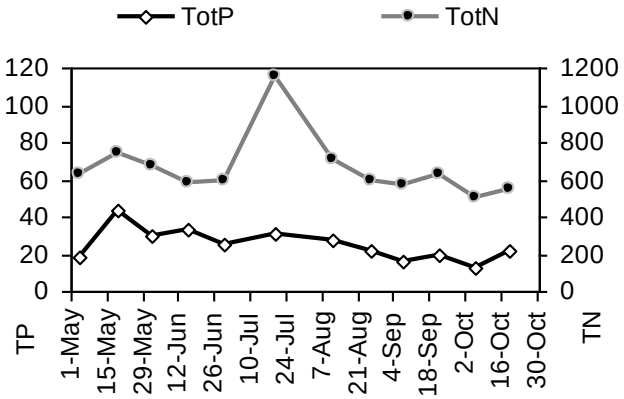

Figure 7. 2008 Little Beaver Lake Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air. In Big Beaver Lake total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 24.0 to 43.3 with an average of 32.9, which suggests that there conditions in the lake were not favorable for nuisance bluegreen growth. Little Beaver Lake ranged from 17.1 to 39.1 with an average of 28.1. This suggests that while overall conditions in the lake are not favorable for nuisance bluegreen algae growth there are times in the season, particularly in the spring, when conditions are favorable for nuisance bluegreen algae growth.

Chlorophyll *a* concentrations in Big Beaver Lake were fairly constant and low throughout the season with pheophytin (degraded chlorophyll) levels below detection levels throughout the sampling period (Figure 8).

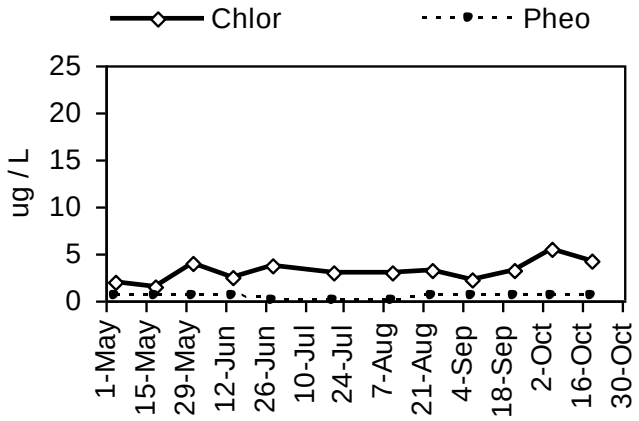

Figure 8. WY 2008 Big Beaver Lake Chlorophyll *a* and Pheophytin concentrations

In Little Beaver Lake chlorophyll *a* concentrations were low with a major peak in the end of July and increasing in fall (Figure 9). The large July 20th TN spike can only be described as an anomaly. The majority of the pheophytin levels were below detection levels throughout the period.

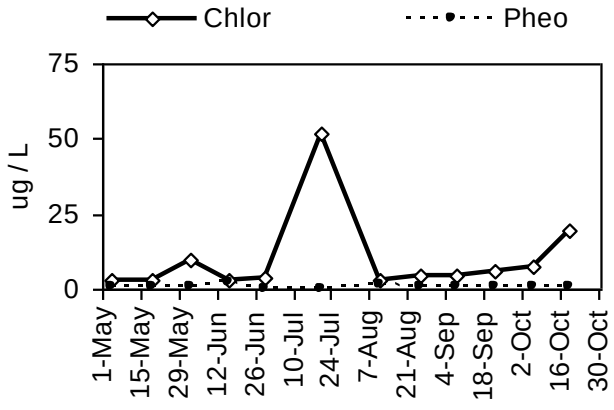

Figure 9. WY 2008 Little Beaver Lake Chlorophyll *a* and Pheophytin concentrations

Profile data on Big Beaver Lake indicates that thermal stratification was present from early summer (the one meter temperature taken from Level I monitoring data with a value of 18 degrees Celsius) and persisted through late summer. Cool temperatures in the deep water may indicate ground water inputs. High concentrations of phosphorus were found in deep water in August, suggesting that anoxia could have triggered a release of phosphorus from the sediments. High ammonia concentrations in the deep water also indicate hypolimnetic anoxia (Table 1).

Table 1. Big Beaver Lake Profile Sample Analysis Results

Lake name	Locator	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH4	Total P	OPO4	UV254	Total Alk
Beaver2	A709	05/18/08	2.4	1		1.60	<MDL	0.430	0.054	0.030	0.0155	<MDL	0.233	13.1
				7	7	<MDL	<MDL	0.430			0.0171			
				14	6			0.455	0.141	<MDL	0.0244	0.0086		
Beaver2	A709	8/24/08	2.4	1	20.5	3.36	<MDL	0.358	<MDL	<MDL	0.0109	<MDL	0.207	13.9
				7	8.5	1.55		0.383			0.0222			
				14	6.5			0.526	<MDL	0.165	0.0795	0.0161		

In the August profile, the total phosphorus (TP) concentration in the deep sample was considerably higher that the deep water, but the ortho-phosphorus (OPO4) was much lower. There are several possible explanations for this:

- There may have been bottom sediments in the sample which would elevate the TP, but not the OPO4,
- The OPO4-rich waters near the water-sediment interface may have mixed up into the water column, effectively diluting the concentration near the bottom.

Chlorophyll *a* profile data indicated that the highest concentrations of phytoplankton are in the surface of the lake on each of the profile dates. Both profile dates have low chlorophyll concentrations suggesting the lake does not have an abundance of phytoplankton and low biological productivity.

Profiles on Little Beaver Lake showed that thermal stratification set up in the lake in early spring and lasted through late summer. In the August profile event the 7 meter sample of TP and TN are more representative of what the 14 meter sample should be and it is undetermined if this error is volunteer or lab generated, but the 7 meter and 14 meter results should be switched. The high TP and TN levels found in the 7 meter sample are representative of what is expected in the anoxic waters that are typical at the bottom of Little Beaver Lake.

Table 2. Little Beaver Lake Profile Sample Analysis Results

Lake name	Locator	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH4	Total P	OPO4	UV254	Total Alk
Beaver1	A757	05/19/08	1.3	1	20	3.25	<MDL	0.746	0.022	0.038	0.0435	<MDL	0.478	9.6
				7	5	<MDL	<MDL	0.536			0.0306			
				14	4.5			0.674	0.139	0.063	0.0790	0.0470		
Beaver1	A757	8/26/08	1.4	1	19.5	4.82	<MDL	0.591	<MDL	0.028	0.0216	<MDL	0.449	10.3
				7	5	<MDL	<MDL	0.985			0.2310			
				14	5			0.557	0.131	0.020	0.0275	0.0089		

Chlorophyll a data suggest the algae are found in the surface waters, although it is not abundant and suggests low primary productivity.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*. The 2008 Big Beaver Lake TSI indicators for chlorophyll *a* and TP were close to each other in the lower range of mesotrophy. The TSI –Secchi indicator was in higher end of the mesotrophic range (Figure 10). The average of TSI indicators in 2008 was slightly lower than last year, but the overall trend suggests that TSI in Big Beaver Lake is remaining static in the lower ranges of mesotrophy.

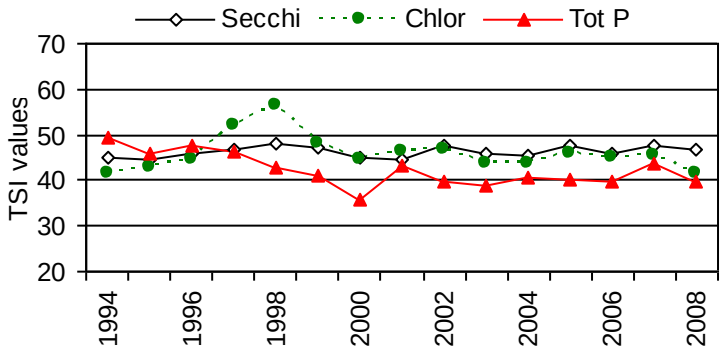

Figure 10. Big Beaver Lake Trophic State Indicators

In 2008, Little Beaver Lake TSI indicators for chlorophyll *a* and TP were close to each other in the upper range of mesotrophy, borderline eutrophy. The TSI-Secchi indicator was at the mid-range of eutrophication (Figure 11). This anomaly in the Secchi reading could be attributed to the dark color of lake water from the Hazel Wolfe wetland which drains into the lake.

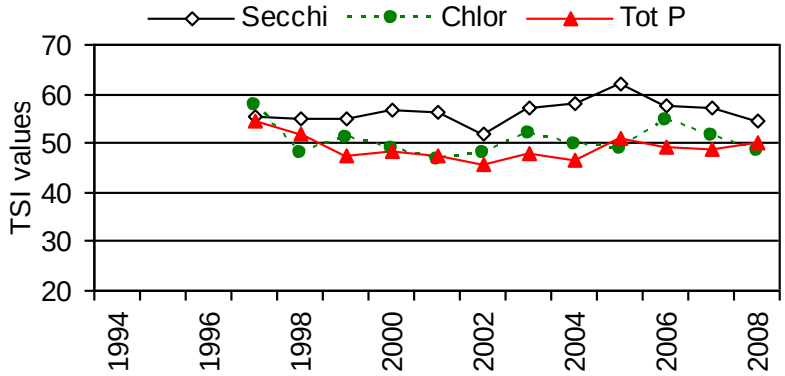

Figure 11. Little Beaver Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Big Beaver and Little Beaver Lakes appears to be stable over the period measured. Big Beaver Lake seems to have a steady TN:TP ratio and is not conducive to nuisance bluegreen algae blooms. However, Little Beaver Lake TN:TP ratio is lower and suggests nuisance bluegreen algae blooms may by an issue, especially in the spring. It is recommended that continued monitoring of nutrient and chlorophyll concentrations be done to assess these conditions in the future.

Pine Lake
Physical Parameters

Excellent precipitation and water level records for Pine Lake were compiled for the 2008 water year. Water levels in the lake responded to winter storm events and then slowly decreased over the course of the water year. Overall, the lake follows the regional pattern of winter high - autumn low stands. Precipitation and lake level data collected since 1995 suggests the lake does rise with the onset of autumn rains and remains slightly elevated through the winter and into spring. However, the range of lake level variation through the year is relatively small, and the highest lake levels don't usually persist longer than a week or two (Figure1).

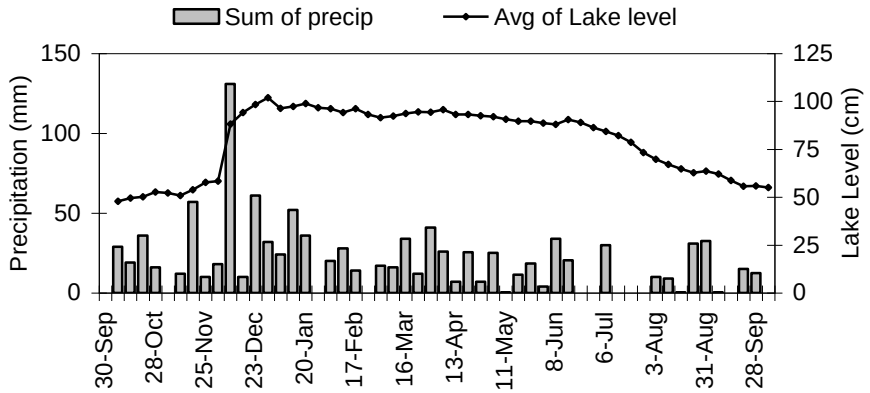

Figure 1. WY 2008 Pine Lake Level and Precipitation

Pine Lake volunteers collected weekly temperature and Secchi transparency data throughout the 2008 water year as well as the data collected during the "Level 2" monitoring season from early May through late October 2008.

Secchi transparency ranged between 3.0 and 6.0 meters (Figure 2). The average was 5.0m, which placed it in the higher range for monitored small lakes in 2008.

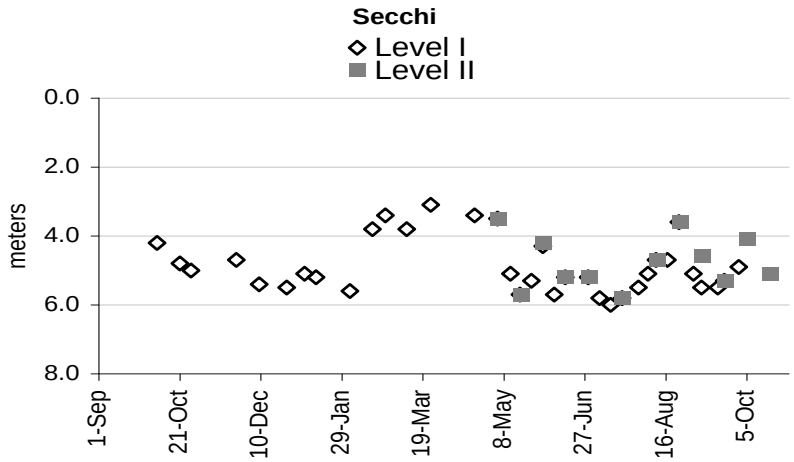

Figure 2. Pine Lake Secchi Transparency

Surface water temperatures ranged between 3.0 to 25.0 degrees Celsius over 2008 with an average of 15 degrees Celsius (Figure 3). The recorded maximum temperature was in the higher range of values reported among the group.

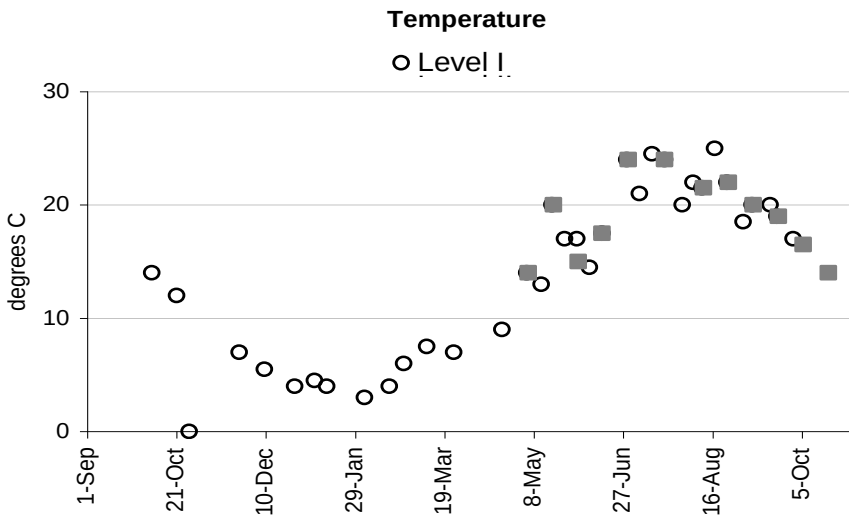

Figure 3. Pine Lake Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

During the monitoring period for Pine Lake, TN and TP values remained fairly consistent throughout the sampling season. TP was highest in the early part of the sampling and was stable throughout the rest of the season (Figure 4).

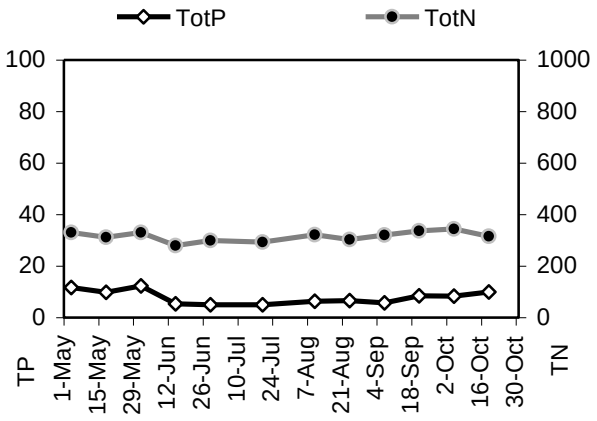

Figure 4. 2008 Pine Lake Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air. In Pine Lake total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 26.8 to 59.8 with an average of 43.7, which suggests that there conditions in the lake were not favorable for nuisance bluegreen growth.

Chlorophyll *a* concentrations in Pine Lake were fairly constant and low throughout the season with a climb occurring in late fall (Figure 5). Pheophytin (degraded chlorophyll) levels remained below detection levels throughout the season except for the last sampling date in October.

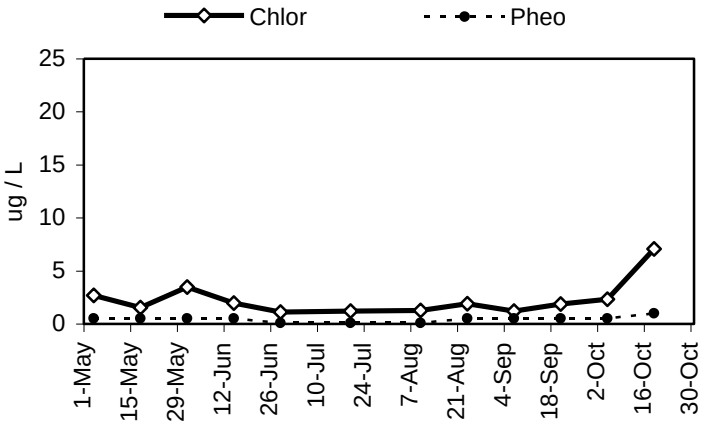

Figure 5. WY 2008 Pine Lake Chlorophyll *a* and Pheophytin concentrations

Profile data on Pine Lake indicates that thermal stratification was present from early summer and persisted through late summer even though the thermocline shifted deeper in the late summer. Higher concentrations of phosphorus were found in deep water in May and August but ammonia was only detected in the May sample (Table 1). This suggest in May there could have been some internal phosphorus cycling caused by anoxic conditions in the bottom waters. However, unlike Beaver Lake, Pine Lake is not anoxic at the bottom in August, it is possible that sediments were present in the bottom sample

Table 1. Pine Lake Profile Sample Analysis Results

Lake name	Locator	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NO2-3	NH4	Total P	OPO4	UV254	Total Alk
Pine	A708	05/18/08	5.7	1	20	1.55	<MDL	0.312	<MDL	<MDL	0.0098	<MDL	0.069	20.9
				5	11.5	1.87	<MDL	0.293	<MDL	<MDL	0.0092	<MDL		
				10	7.5			0.399	0.043	0.065	0.0162	0.003		
Pine	A708	8/24/08	3.6	1	22	1.9	<MDL	0.303	<MDL	<MDL	0.0066	<MDL	0.0685	21.6
				5	21	2.08	<MDL	0.319	<MDL	<MDL	0.0086			
				10	9.5			0.557	<MDL	<MDL	0.0614	<MDL		

Both profile dates have low chlorophyll concentrations suggesting the lake does not have an abundance of phytoplankton and low biological productivity.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a*. The 2008 Pine Lake TSI indicators for chlorophyll *a* and Secchi were close to each other in the high range of oligotrophy. The TSI –TP indicator was in lower end of the oligotrophic range (Figure 6). The average of TSI indicators in 2008 was fairly consistent with previous years with the overall trend suggesting that TSI in Pine Lake is remaining static in the upper ranges of oligotrophy.

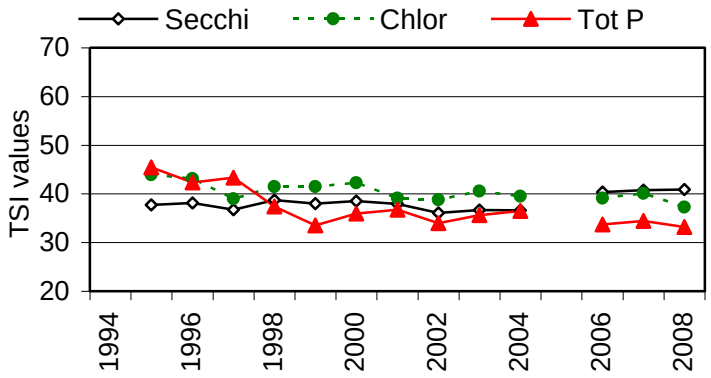

Figure 6. Big Beaver Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Pine Lake appears to be stable over the period measured. There may be a pattern of elevated late season TN and TP values. High average N:P ratios could indicate conditions are not favorable for nuisance bluegreen algae blooms. It is recommended continued monitoring of nutrient and chlorophyll concentrations occur to assess future conditions and track any changes.